LASERS IN CUTANEOUS AND AESTHETIC SURGERY

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Delivery Devices

Articulated Arm

An articulated arm is a precision assembly of hollow tubes, mirrors, and joints. It permits the delivery of a light beam, through simple reflection, from the laser head to the operating site. The beam emerging from the distal end of the arm retains the same spatial and temporal characteristics of the original laser beam and can be focused or defocused by lenses to produce the spot size and resulting power density appropriate for a particular application.

The articulated arm is widely used for CO_2 lasers, whose infrared beam cannot pass through flexible quartz fiberoptics. Though these devices make the laser considerably more versatile, the complex mechanical joints render them cumbersome. Rough treatment of the delicate mirrors, or poor maintenance, can lead to degradation of the beam quality. Moreover, if a second laser beam is employed for aiming (as in the CO_2 laser), it is possible for the two beams to be misaligned, resulting in inaccurate targeting of the treatment beam.

Micromanipulators

Many applications of laser energy require or benefit from manipulation of the laser beam through an optomechanical mechanism. Such a device, referred to as a *micromanipulator* or *joystick,* is generally used with a surgical microscope. As the joystick is manipulated the laser beam is moved around the surgical site while in direct magnified view of the surgeon. The motion of the beam can be controlled directly by the surgeon or directly by a computer. Computer or microprocessor control permits the surgeon to simply outline an area for treatment, and then the computer scans the beam within the outlined area.

Scanners

With the advent of the scanner, an accurate and repeatable microprocessor-controlled delivery of pulsed or cw laser output was possible, circumventing the problems posed by inconsistent freehand methods. The scanner's nonaligned treatment pattern allows the thermal energy in adjacent tissue to cool adequately between pulses of laser energy. The scanner has proved of value to both dermatologists and plastic surgeons.

Fiberoptics

The most common and convenient way of delivering laser energy to tissue is through flexible optical fibers. They can be used with micro-

manipulators or handpieces or can be passed through most standard operating endoscopes. Fiberoptics are composed of two or more concentrically arranged optical materials, and light is carried along the length of the fiber by total internal reflection.

Surgical fiberoptics are relatively inexpensive and are far more convenient than articulated arms. They can carry power from any cw laser that operates in the visible or near-infrared regions of the spectrum. Disposable fibers and fibers with integrated specialized handpieces have now largely replaced reusable fibers, which required periodic recleaving or polishing of the distal quartz surface.

Once light is captured in the fiber, it is transmitted the length of the device, so that there is no alignment problem with aiming and treatment beams. On the other hand, the beam does lose coherence as it passes down the fiber, resulting in a slightly divergent beam and increased spot size at the treatment site. Lenses and contact probes can be used to focus this emergent beam.

Endoscopic Devices

In the beginning, endoscopy was an exclusively diagnostic technique, though early in the 20th century limited therapeutic procedures were carried out using this technology. Over the past decade, small-incision endoscopic surgery has revolutionized the treatment of numerous diseases. This is attributable to the simultaneous development of practical laser systems (capable of vaporizing and coagulating via flexible fiberoptics) and the achievement of technological advances in high-resolution charge-coupled device (CCD) cameras; endoscopic ligating, suturing, and clipping devices; safer electrosurgery instruments; flexible endoscopes; and an expanding array of fine manipulating instruments. Though lasers do not deserve sole credit for this revolution, and are not the appropriate endoscopic treatment modality in all settings, the ability to cut or ablate tissue endoscopically with simultaneous hemostasis has largely eliminated one of the most problematic aspects of small-incision surgery.

Contact Nd:YAG Laser

The ultimate concern in laser surgery is the tissue effect. Photothermal lasers produce their surgical effect through the transformation of light energy into heat, usually as a result of light energy being absorbed by tissue. When affixed to the distal end of a fiberoptic, contact laser probes can alter the optical, mechanical, and thermodynamic properties of the delivery device.

Whereas light emerges from a fiberoptic as a slightly divergent beam, it refracts within a contact tip. Depending on such factors as the angle of convergence and the size and shape of the distal face, the beam can be emitted as a divergent or convergent beam or it can be

laterally radiated from the sides of the contact tip. Contact probes are made of durable, rigid materials with high melting points. They can be used mechanically and brought in contact with tissue, unlike a bare fiberoptic that can break or melt easily. A 2.5-mm-diameter cylindrical probe can provide a surface area to tamponade a bleeding vessel, together with a laser power density suitable for coagulation. A contact laser scalpel, tapered to 0.2 mm in diameter, can provide the small spot size and high-power density needed for fine incision with minimal coagulation.

The most important property of contact laser probes is the manner in which they titrate the light and thermal energy that emerges from the delivery device. Rather than delivering a beam of pure light energy that is converted to heat entirely within the tissue, special absorbant coatings and surfaces on the contact laser probes can transform a predetermined portion of the light energy into heat at the probe's surface. This modifies the surface temperature and tissue temperature gradient to suit the surgical need. Therefore, rather than selecting a laser type according to the absorption coefficient that produces the desired effect in the tissue, one can choose the contact laser probe or scalpel that creates the appropriate temperature gradient.

Contact laser probes can be employed with any cw laser operating in the visible or near-infrared regions of the spectrum. One cannot, however, increase the penetration of a laser beam with a relatively high absorption coefficient, such as the green light lasers. Though a contact probe will enable them to cut well, it cannot increase their capacity for deep coagulation. With longer-wavelength lasers, such as the diode or Nd:YAG, it is possible to use the full penetration or, when deep thermal effects are not wanted, to reduce penetration by transforming more light energy into heat at the probe surface. In this way, a single laser can be made to mimic the tissue effects of many lasers of different wavelengths, while adding optical and mechanical features not available with a simple fiberoptic device.

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